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Measurement of Uranium Concentration in Basrah Soils Using the CR-39 Detector

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ABSTRACT

The amount of uranium in soil samples collected from a variety of residential, industrial, and agricultural sectors in the southern Basrah governorate in southern Iraq was determined using the neutron activation technique for solid-state nuclear track detectors CR-39. According to the findings, uranium concentrations in soil samples ranged from 0.65 ppm to 2.67 ppm. Soil samples were taken from a depth of 15 cm. The results were matched to publicly available data and determined to be within acceptable bounds.

1. Introduction

As a natural radionuclide, uranium is a silvery, glossy metal with a long half-life. Uranium is the heaviest element in the world. Due to its radioactivity, it is one of the most serious pollution hazards. Uranium and its compounds are very poisonous, presenting a danger to people's health and the environment (Al-Hamzawi, et al., 2015; Zou, et al., 2011). Uranium is a common element that may be found in solid, liquid, or gaseous forms. It might be found in food, water, soil, rocks, natural materials, and the environment. Uranium produces uranium oxide, silicates, hydroxides, and carbonates quite easily when it reacts with other elements (Sweaf & Salman, 2019; Banks, et al., 1995). The solubility of uranium compounds determines their physiological activity. The chemical toxicity of soluble uranium is controlled, whereas the radiological characteristics of insoluble (less soluble) uranium are regulated. However, due to its sluggish absorption via the lungs and extended retention period in human tissues, it will do the most harm to internal organs through radiological damage (cancer mortality risk) rather than major a chemical threat to the kidneys (Todorov & Ilieva, 2005). Uranium may enter the human body through a number of routes. It enters the body either directly via inhaling uranium-bearing dust particles or drinking uranium-contaminated water, or indirectly through the food chain from the fertile soil layer (AL-Hamzawi, et al., 2013; Al-Hamzawi, et al., 2015). When measuring uranium trace levels in geological and biological materials, it is more efficient to use a CR-39 detector (Al-Hamzawi, et al., 2015; Sweaf & Salman, 2019; Khan & Qureshi, 1994). Because of the relevance and impact of the problem on the environment and human health, studies investigated looked into the concentration of uranium in soil samples (Gamboa, et al., 1984; Oufni, 2003). The purpose of this study is to examine the uranium content in selected soil samples taken from diverse residential, industrial, and agricultural sectors in Southern Basrah governorate in southern Iraq using the neutron activation technique for nuclear track detectors CR-39. This study was carried out in the governorate of southern Basrah due to a lack of previous research and the creation of a database on the number of uranium concentrations in soil samples.

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2. Materials and Methods

2.1. The Collecting of Samples

In this work, 40 soil samples were collected from 40 different locations in the southern Basrah governorate of southern Iraq, one from each (see Figure 1). Soil samples were collected at depth inside the soil (15cm). Table 1 depicts the research areas, which comprised residential, agricultural, and industrial zones. After cleaning 40 soil samples and removing stones, pebbles, and root portions, the needed quantity for the fission-track analysis approach was obtained. The samples were kept in polypropylene vials labeled with sample codes.

2.2. Experimental Method

Solid-state nuclear track detector was used to quantify the uranium content in soil samples (CR-39, Pershore Moulding Ltd, UK). The soil samples were dried in an electric oven at 70°C for 6 hours, after which they were ground with a grinder. (0.5 g) powder soil was combined with (0.1 g) methylcellulose as a binder. A manual piston with a diameter of 1 cm and a thickness of 1.5 mm was used to crush the mixture into a pellet. A CR-39 track detector with a size of (1.5×1.5 cm) was coated on both sides of the pellets. The pellets were subsequently irradiated in a paraffin wax dish for 7 days at a distance of 5 cm from the neutron source (Am-Be) with a thermal flounce of (3.024×10^5 $n.cm^{-2}.s^{-1}$) to cause latent damage on the detector due to the ^{235}U reaction (n,f). After the irradiation technique, the detectors were chemically etched in (NaOH) solution under controlled conditions, as described before (Al-Hamzawi, et al., 2014; Al-Hamzawi, et al., 2015). The densities of induced fission tracks were measured using an optical microscope with a magnification of 400×, and the tracks were seen using an optical camera. The density of fission tracks (ρ) was calculated by dividing the average of tracks by the area of field view, as shown in Equation 1:

$$\text{Track density } (\boldsymbol{\rho x}) = \frac{\text{average of tracks}}{\text{area of field view}} \quad \textbf{(1)}$$

2.3. Calculation

Using the equation previously stated (Al-Hamzawi, et al., 2015; Sweaf & Salman, 2019), the uranium content of soil samples was determined by comparing track densities detected on the detector of soil samples to those found on the detector of standard samples.

$$\boldsymbol{Cx = Cs\ \frac{\rho x}{\rho s}} \quad \textbf{(2)}$$

where ρ_x and ρ_x represent the induced fission track density in (tracks/mm^2) for unknown and standard samples, respectively, and C_x and C_S represent the uranium concentrations in unknown and standard samples, respectively, in (ppm).

Fig. 1. Southern Basrah governorate on a map of Iraq

Table 1
Uranium content in Southern Basrah Governorate soil measured up the SSNTDS technique

No of site	Location of samples	The concentration of Uranium (ppm)
S1	Sea side Dora	1.7
S2	Sihan	1.3
S3	Al Siba	1.27
S4	Ras Al Bisha	1.52
S5	FAO Center	1.43
S6	Al Mumlahih	1.41
S7	Hamdan	1.53
S8	Abu Mughira	1.58
S9	Al-Saraji	1.4
S10	mhjran	1.45
S11	muhilah	1.5
S12	Jaykur	1.63
S13	Al Baradhaiya	1.43
S14	Um Qasr farm 1	1.62
S15	Um Qasr farm 2	1.4
S16	Um Qasr farm3	0.65
S17	Um Qasr farm4	1.3
S18	Um Qasr farm5	0.94
S19	Um Qasr farm6	0.97
S20	Um Qasr Center	1.7
S21	Al Hadaama	1.83
S22	Khor Al Zubair Center	2.27
S23	Khor Al Zubair Farm1	1.8
S24	Khor Al Zubair Farm2	1.6
S25	Khor Al Zubair Farm3	2.1
S26	Zubair Center	2.49
S27	Al Easkari district	1.6
S28	Al Shuhada district	2
S29	Al Khatwa district	1.46
S30	Al Sahafiiyn district	1.89
S31	Al'athar	1.2
S32	Al Marbad	1.71
S33	Al Qaim District	1.8
S34	Al Burjsia	1.35
S35	Al Shuaiba Center	2.67
S36	Al Shuaiba farm1	1.4
S37	Al Shuaiba farm2	1.5
S38	Al Shuaiba farm3	1.8
S39	Al Shuaiba farm4	1.42
S40	Al Shuaiba farm5	1.2

3. Results and Discussion

Table 1 shows the analytical data acquired from the soil samples, which are used in this investigation. The greatest uranium content in a surface soil sample was 2.67 ppm in sample S35 from Al Shuaiba Center, while the lowest was

0.65 ppm in sample S16 from Um Qasr farm3, to have uranium concentrations in soil samples taken from the surface averaging of 1.38222 ppm. The mean uranium concentration in southern Basrah governorate surface soil samples is below the permissible threshold indicated by (Bem & Bou-Rabee, 2004). The findings reveal that as soil depth increases, the amount of uranium in the soil decreases. The cause of such outcomes may be traced back to erosion processes and the washing away of soil surface layers. The highest amount of radioactivity is seen near the soil surface during the first months following soil contamination, where winds and rains can remove up to 90% of radioactive material (Barišić, et al., 1999). In addition to the mineral composition of Iraqi soil, which contains a considerable amount of calcium carbonate, iron oxides, and aluminum, the interaction of these components with the solid component of the soil exposes the soil's capacity to retain radioactive contaminants and hinder their mobility.

Figure 2 depicts the overall average uranium concentration in southern Basrah governorate soil samples as a function of location. The maximum uranium content in soil samples was 2.67 ppm, which was detected in Al Shuaiba Center. This result is lower than the uranium concentration safety threshold of 2.8 ppm. This outcome can be linked to the fact that during the Gulf war, this region was heavily bombarded with uranium weapons.

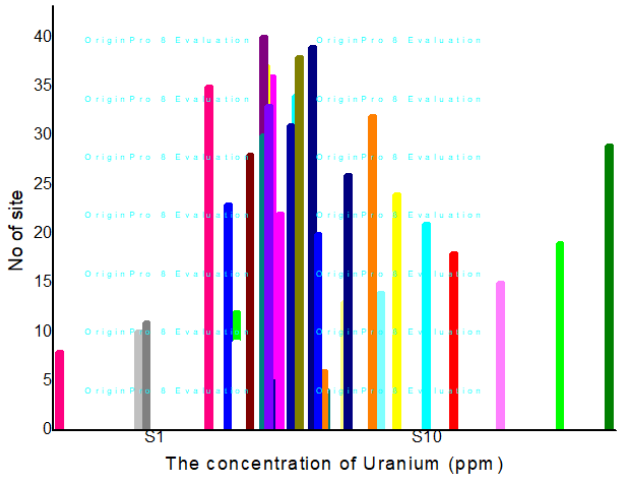

Fig. 2. The average uranium content in soil samples as a function of geographic location

During the Gulf conflicts, human activity and the exposure of certain industrial zones to uranium contamination resulted in such outcomes. The presence of uranium in agricultural soil samples may be connected to fertilizer use in agricultural areas; the presence of uranium in soil samples is classified as industrial > agricultural > residential.

The findings of this experiment were compared to those of other researchers in different areas, and the results are reported in Table 2. Because this was the first study of its kind to look at uranium levels in soil samples from different parts of the Northern Basrah governorate, the findings are now being used as a source of information for future studies.

Table 2
Comparison between the current work's uranium content (ppm) and the other sites

No.	Places	Average	Range	References
1	Mexico	.....	2.6 -13.7	Gamboa, et al., (1984)
2	India	4.62	1.47- 10.66	Kakati, et al., (2013)
3	Turkey	.....	1.01 - 11.7	Baykara & Dogru, (2006)
4	Brazil	3.21	.....	Geraldo, et al., (2010)
5	Baghdad, Iraq	1.05	0.40 - 2.53	Kadhim & Kadhim, (2018)
6	Thi-Qar, Iraq	2.077	0.77 - 2.89	Mansour, et al., (2015)
7	Southern Basrah	1.5705	0.65-2.67	Present work

4. Conclusion

Solid-state nuclear track detectors (SSNTDs) were used to evaluate uranium contents in soil samples. The results of this research showed that the concentration of uranium increases in industrial places more than in residential areas, but the results were within the permissible limits and do not lead to concern at the present time.

Competing Interests

The authors have declared that no competing interests exist.

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